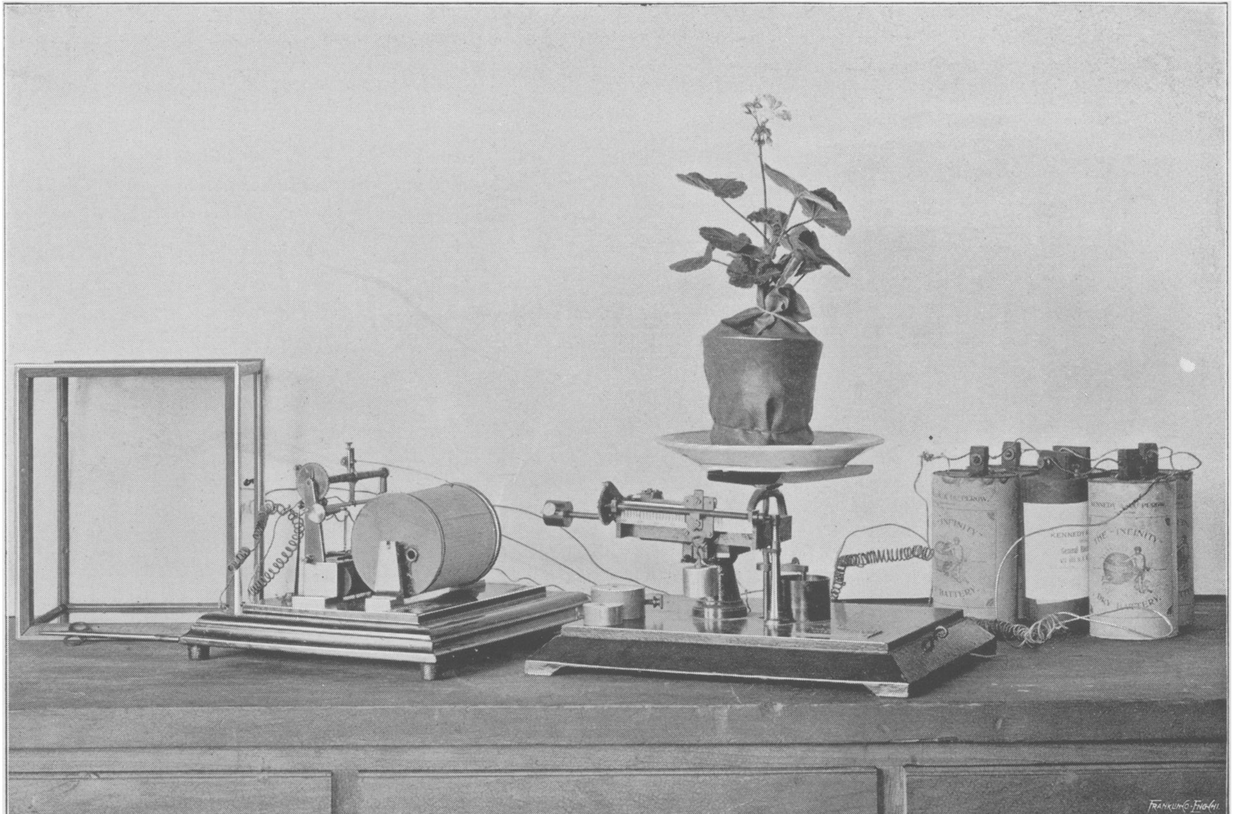


WOODS on APPARATUS for RECORDING TRANSPIRATION.

BOTANICAL GAZETTE

NOVEMBER, 1895.

Recording apparatus for the study of transpiration of plants.[1]

ALBERT F. WOODS.

WITH PLATE XXX.

Of the various methods devised for determining the amount of water evaporated by plants, none is so satisfactory as the direct one of weighing the plant at given periods. Weighings, however, as ordinarily carried on, are more or less unsatisfactory, for unless the operation is repeated at short intervals, a broken record is the result. To obviate this difficulty, various devices have been used. Some of these weigh the loss from the plant direct, while others operate by the indirect method of weighing the water absorbed by calcium chloride, sulphuric acid, etc. Of the last mentioned class the Anderson registering balance[2] is an admirable device which with some slight modifications might be made to record directly loss in weight. At the suggestion of Mr. B. T. Galloway, the writer has recently made some changes in Marvin's recording rain and snow gauge which fits it for very satisfactory work in measuring continuously the loss of water from transpiring plants. Prof. Marvin, of the United States Weather Bureau, very kindly assisted us in making the changes. The apparatus consists essentially of two parts, a balance and a register. (PLATE XXX.) The two parts are in an electrical circuit which is opened or closed whenever the equilibrium of the balance is disturbed. When the circuit is closed, the movement of the armature of the magnet mounted on the left arm of the balance engages a notched wheel which turns a long screw set parallel to the beam. This screw works in a half nut attached to the carriage of the

---

[1]Read before section G, A. A. A. S., Springfield meeting, August, 1895.

[2]Bull. Geol. and Nat. Hist. Surv. Minn. 9: 117–180. 27 S. 1894.

counterweight and is adjustable, so that the weight may be set at any point along the beam. For recording evaporation, a left hand screw is used, moving the weight from left to right. As evaporation from the plants goes on, the right arm of the scale rises, thus closing the circuit above the beam. The armature of the magnet is then attracted and turns the screw carrying the counterweight; at the same time the pen on the register is carried along by a similar mechanism. This is continued until the balance is brought to equilibrium and the circuit broken. Further evaporation causes a repetition of the process. The beam is protected from objectionable up and down swing by a dasher attached to the vertical stem supporting the scale pan and working in a cup of glycerin.

The register is shown on the right of the plate. It is exactly the same as that used for recording rainfall. Prof. Marvin describes it as follows:[3] "The record cylinder is mounted upon a horizontal axis with the clock movement inside. The cylinder makes one revolution in twelve hours. The mechanism giving motion to the pen consists of an electro-magnet and armature similar to those on the weighing gauge, and of a notched wheel fixed upon the end of a screw having cut upon it both a right and left hand thread of coarse pitch, viz., three threads to the inch. A cylindrical sleeve slides upon this screw, being guided by a slender rod below and parallel to the screw. A slender spring, with the recording pen attached to its point, is connected adjustably to the sleeve by a double friction joint which enables the pen to be set with great facility, the friction holding it accurately and firmly where placed.

"The armature of the electro-magnet engages directly the teeth of the notched wheel upon the right and left hand screw in such manner as to cause it to revolve tooth by tooth, always in one direction, with each vibration of the armature. The sleeve moving upon the screw is fitted with a crescent-shaped attachment which enters the thread of the screw. When the sleeve is set with the crescent in the thread at one end of the screw, the pen will, when the screw is revolved, be moved to the opposite end, the crescent-shaped piece being then guided into the other thread, and thus, upon continued rotation of the screw, causing the pen to return again to the

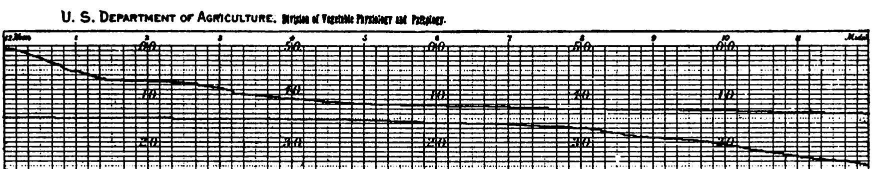
[3] U. S. Weather Bureau. Cir. E, Instrument Room.

starting point. Here the crescent nut will again pass into the thread first followed, and again carry the sleeve across the screw. The reciprocating motion of the pen thus secured is strictly in a straight line, and the subdivisions of the scale of the record sheet are equal throughout, conditions that are extremely desirable, especially in a recording rain gauge where rate of rainfall is to be obtained."

The equal subdivisions of the scale thus obtained also greatly facilitate the determination of the rate of evaporation.

The record sheet is divided into hours by lines running parallel to the axis of the cylinder; the hours are subdivided into spaces of ten minutes. Lines representing grams are drawn at right angles to the hour lines. The value of these spaces can be regulated by varying the weight of the counterpoise on the balance. Our instrument is set up so that each space equals one gram. One movement of the armature carries the counterpoise a distance equal to one-tenth of a gram and the pen at the same time moves across one-tenth of a gram space on the record sheet. Once across the sheet equals fifty grams. When the pen has recorded this amount it passes back, making the record in the other direction as before explained.

Below is shown a record of evaporation from a fuchsia from 12 M. March 16th to 12 M. March 18, 1895. It is one sheet of



a continuous record for the month of March. The pen was started at 12 M. March 16th at the top of the sheet. From 12 M. to 1:25 P. M. the loss was at the rate of one gram for each ten minutes. During this time the plant was exposed to direct sunlight. At 1:25 a screen was placed between the plant and the sun. The rate of evaporation was greatly

checked, being only about one-tenth of a gram in ten minutes. At 2:30 P. M. the screen was removed. The intensity of the light was much lower than from 12 to 1:25, but greater than what the plant had been exposed to behind the screen. The increase in loss is proportional to the increased intensity of the light. The total loss from 12 M. to 6 P. M. is seen to be 12.1^{gm} from 6 P. M. to 12 midnight nine-tenths of a gram, 12 midnight to 6 A. M. 1^{gm}, 6 A. M. to 12 M. 9^{gm}, 12 M. to 6 P. M. 6.5^{gm}.

March 16th was clear, the 17th two-tenths cloudy, the 18th eight-tenths cloudy. The total amount lost for the whole period was 39^{gm}. This brief explanation in connection with the record will show how easily and accurately comparisons may be made for any period of time or the total evaporation determined at any time during the experiment. With automatic devices for recording temperature, humidity, intensity of light, and barometric pressure, it will be possible to obtain data on the much talked about but little understood problems of transpiration. The instrument can be very easily modified so that it will record either gain or loss in weight. With the help of Prof. Marvin we hope to simplify it and increase its range of usefulness in physiological work. Plate XXX is reproduced from a photograph of the complete apparatus as at present used.

Division of Vegetable Physiology and Pathology,
U. S. Department of Agriculture, Washington, D. C.